Joint Probability Density Functions of Cloud Objects

(Preliminary Results)

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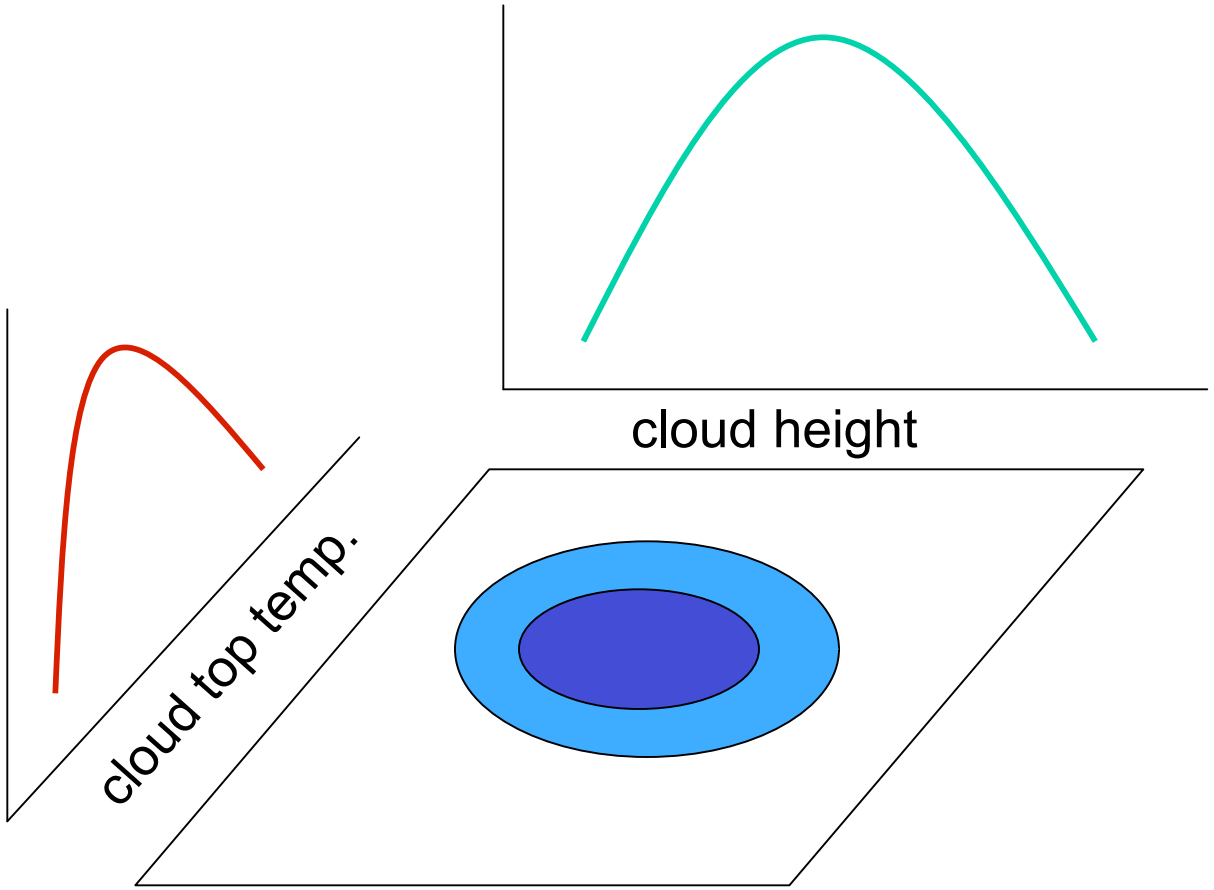
Introduction

- Joint PDFs of satellite footprint data are used to measure how one cloud property changes with respect to another for collections of cloud objects.
- These joint PDFs can be used to validate or formulate physical hypotheses by comparing the actual joint PDF to a synthetic "uncorrelated" joint PDF.

Data

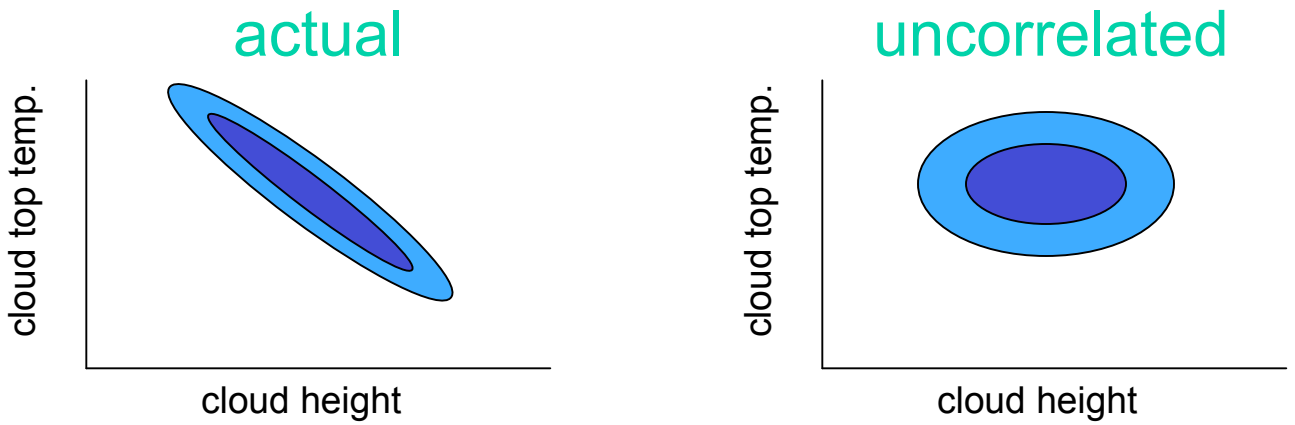
- Large (D_{eff} > 300 km) cloud objects were identified from CERES-TRMM SSF data for Jan-Aug 1998.
- Selection criteria:
  - Deep convection: z_{top}>10 km, τ>10, f = 100%
  - Boundary-layer stratus: z_{top}<3 km, f = 100%
  - Boundary-layer stratocumulus: f = 40-99%

Construction of an uncorrelated PDF

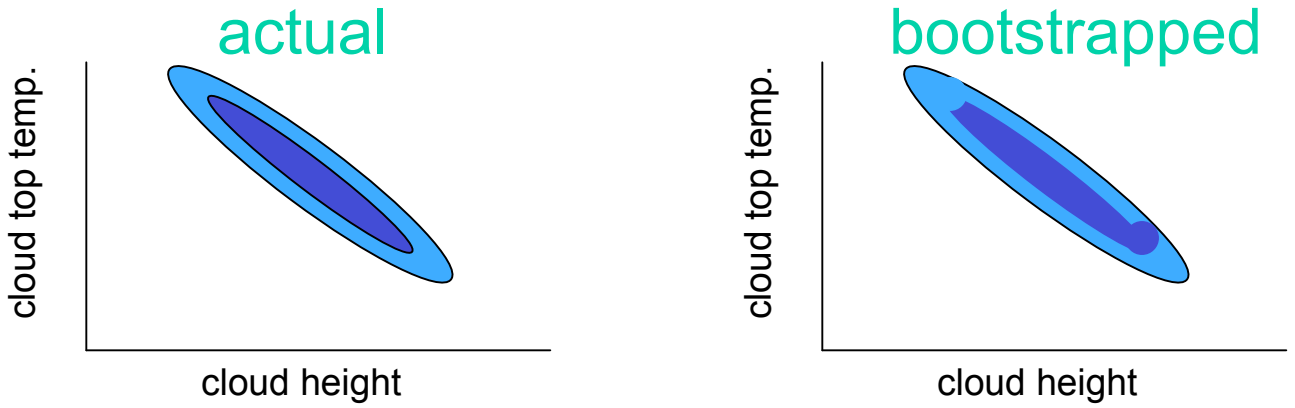


Hypothesis Test

Calculate difference between actual joint PDF and uncorrelated joint PDF.

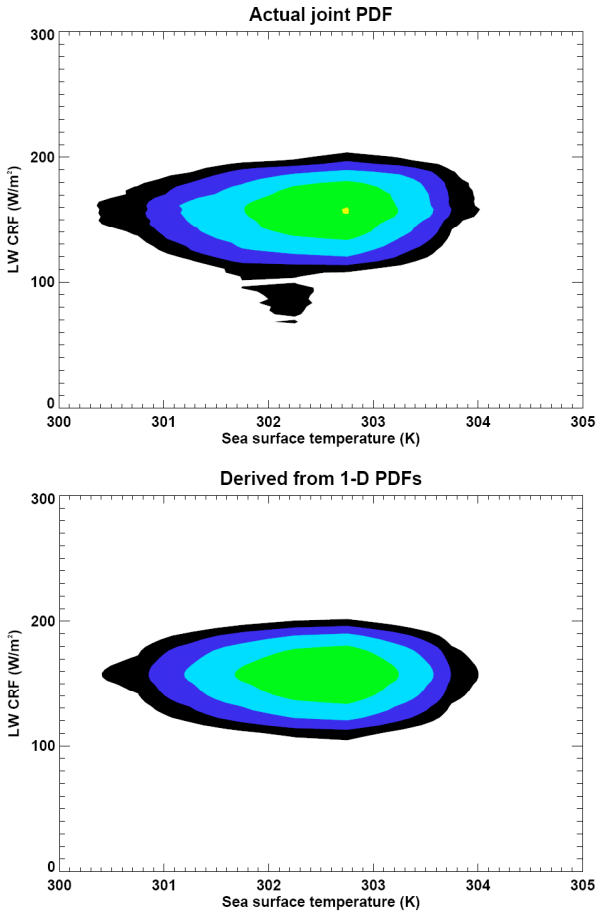


Compare this difference to the differences between actual joint PDF and many (5000) bootstrapped joint PDFs.



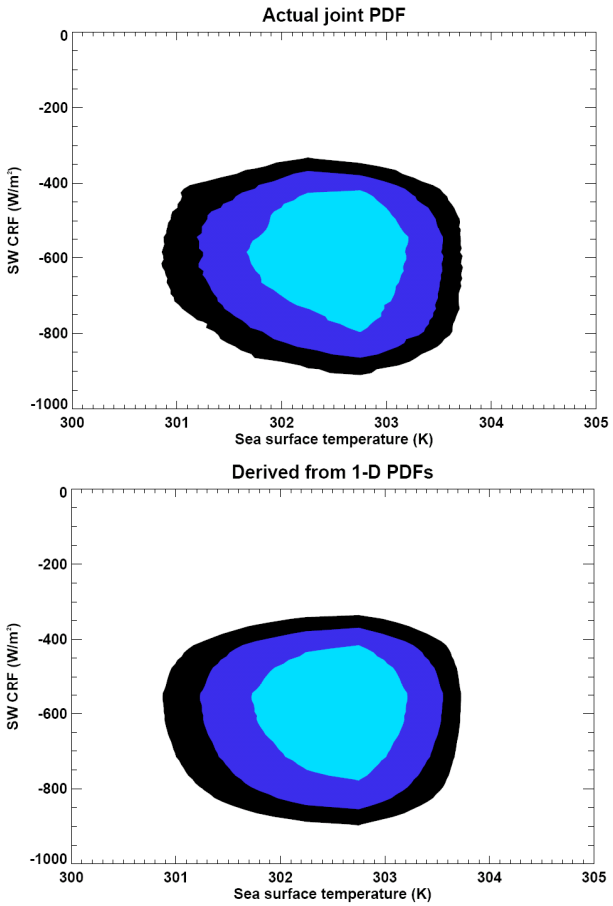
Results – Deep convection

LW CRF vs. SST



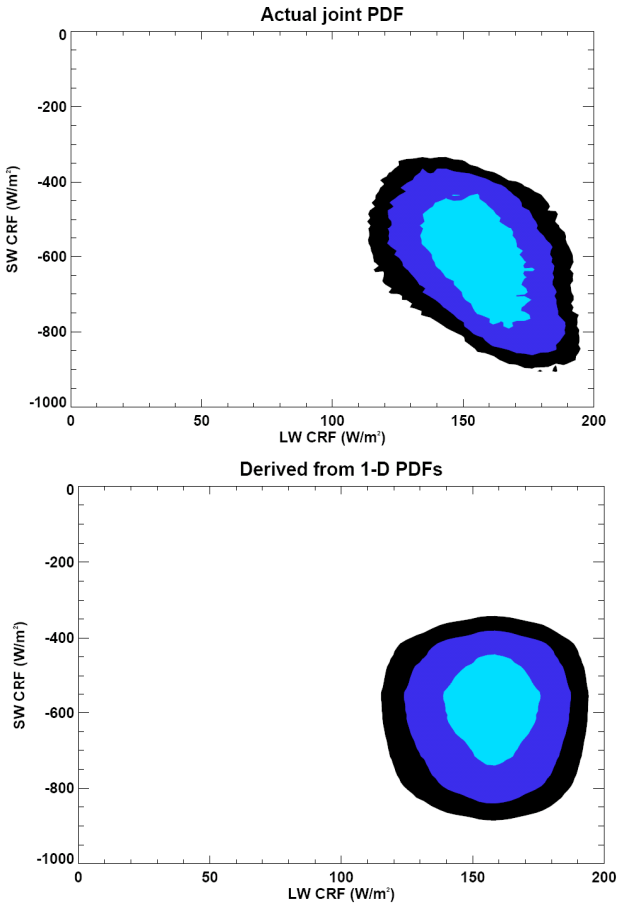
p = 0.53

SW CRF vs. SST



p = 0.99

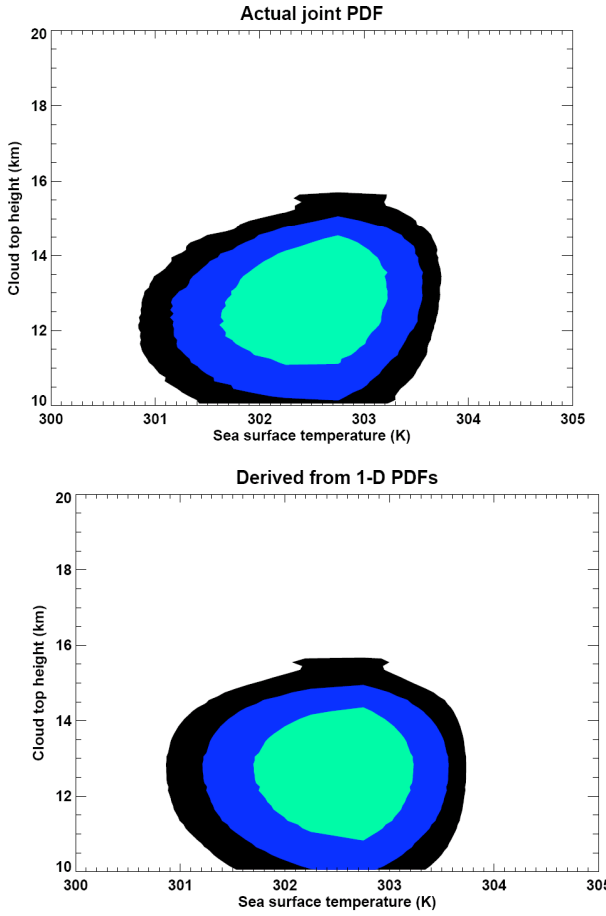
SW CRF vs. LW CRF



p < 0.01

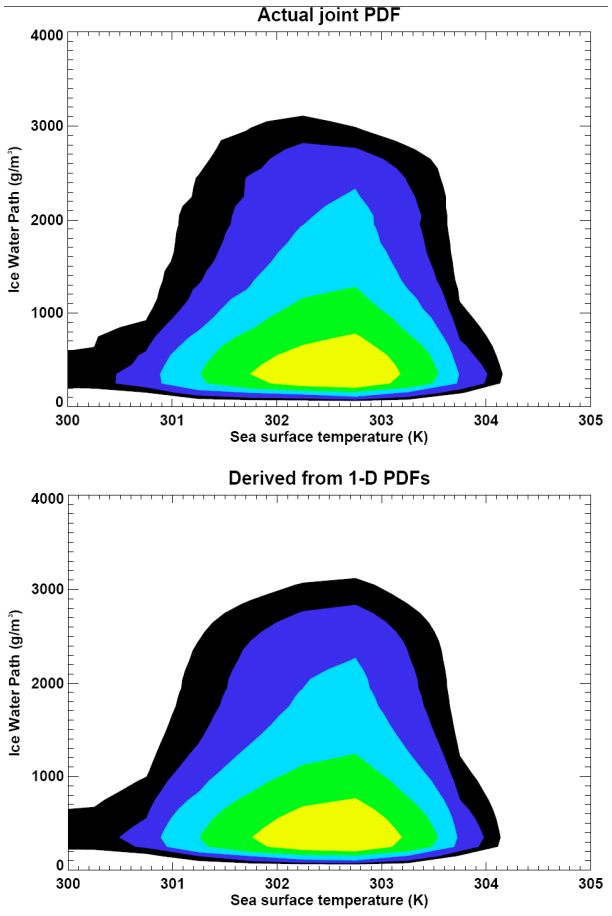
Results – Deep convection

Cloud top vs. SST



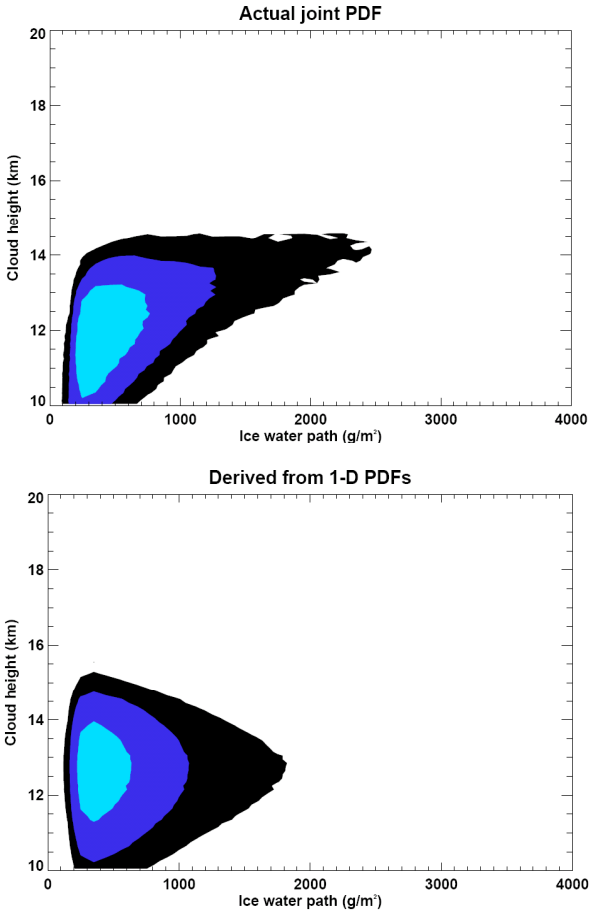
p = 0.06

IWP vs. SST



p = 0.99

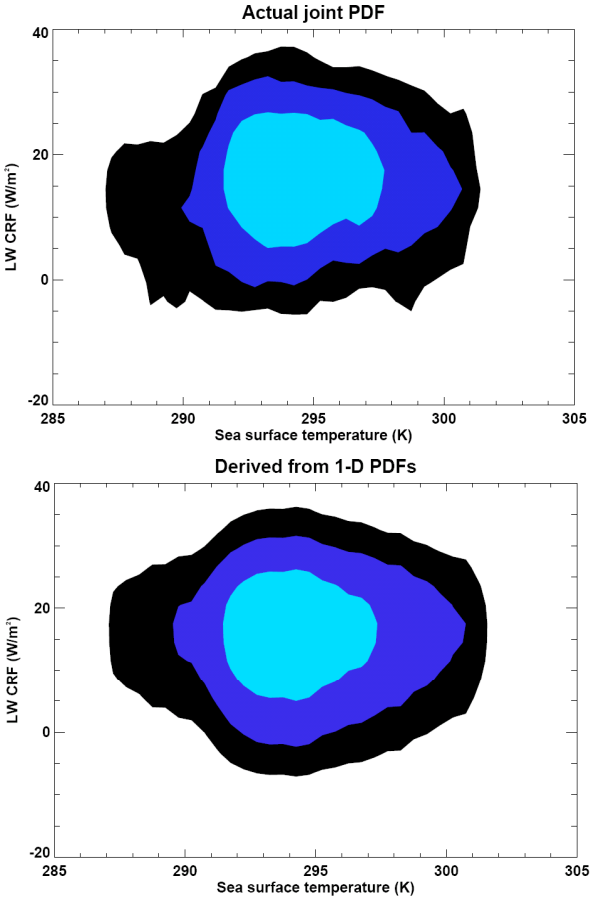
Cloud top vs. IWP



p < 0.01

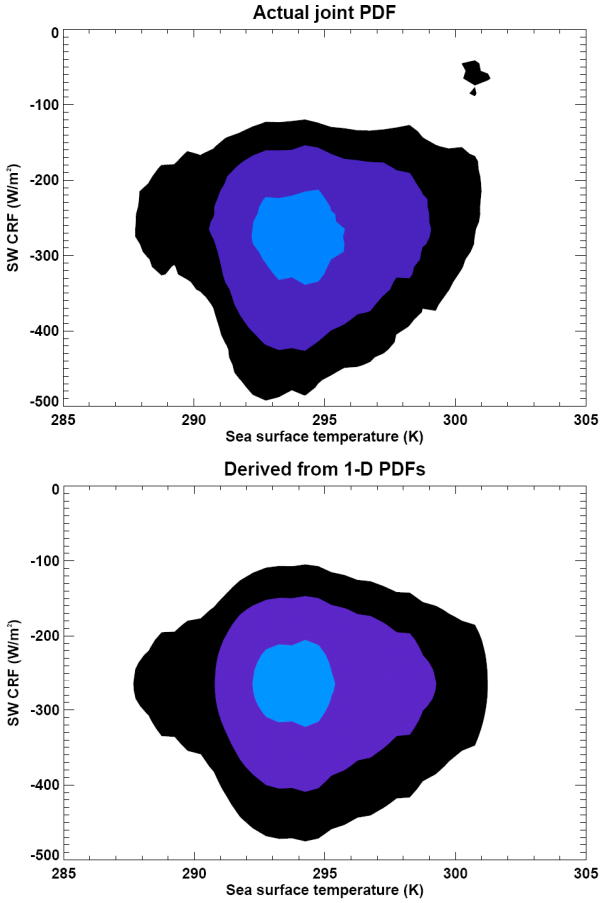
Results – Boundary-layer stratus

LW CRF vs. SST



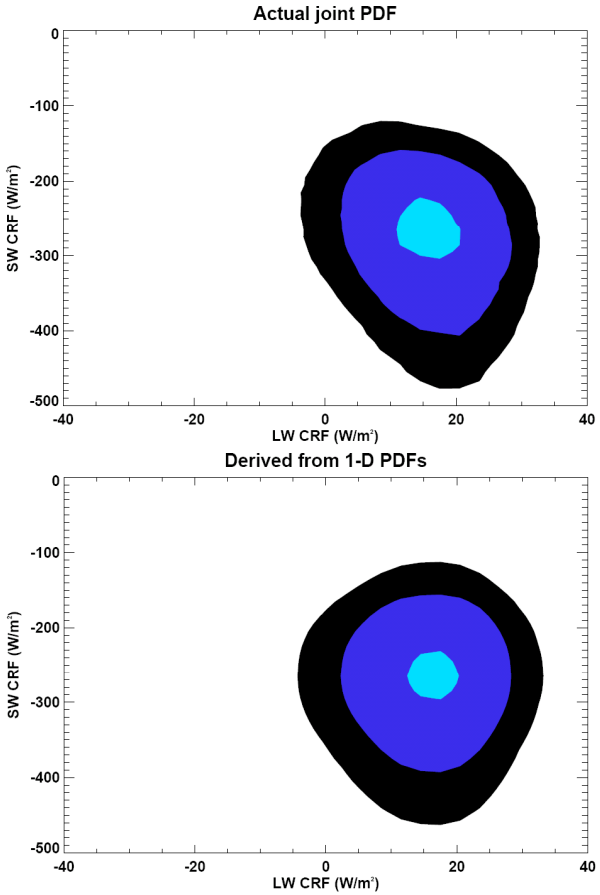
p = 0.96

SW CRF vs. SST



p = 0.24

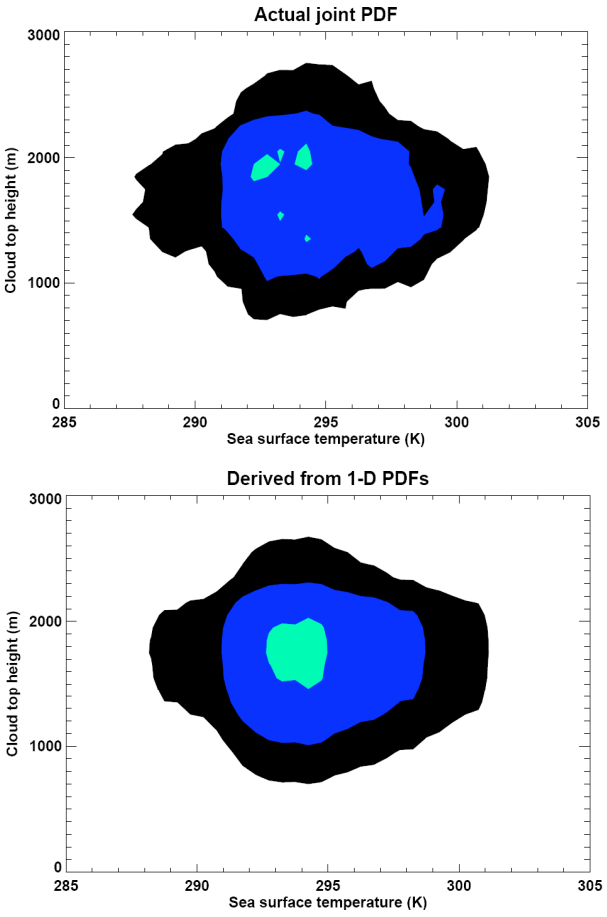
SW CRF vs. LW CRF



p = 0.01

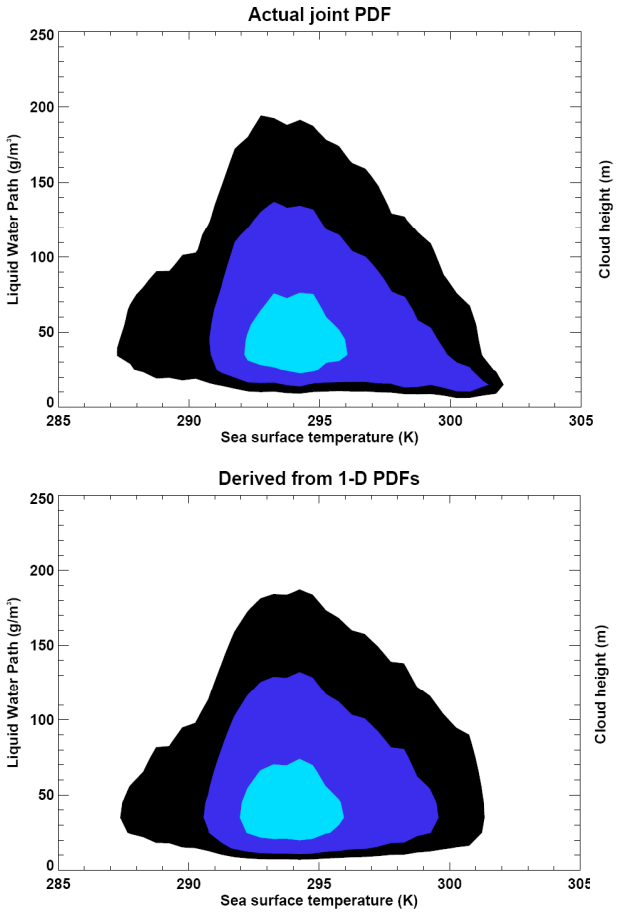
Results – Boundary-layer stratus

Cloud top vs. SST



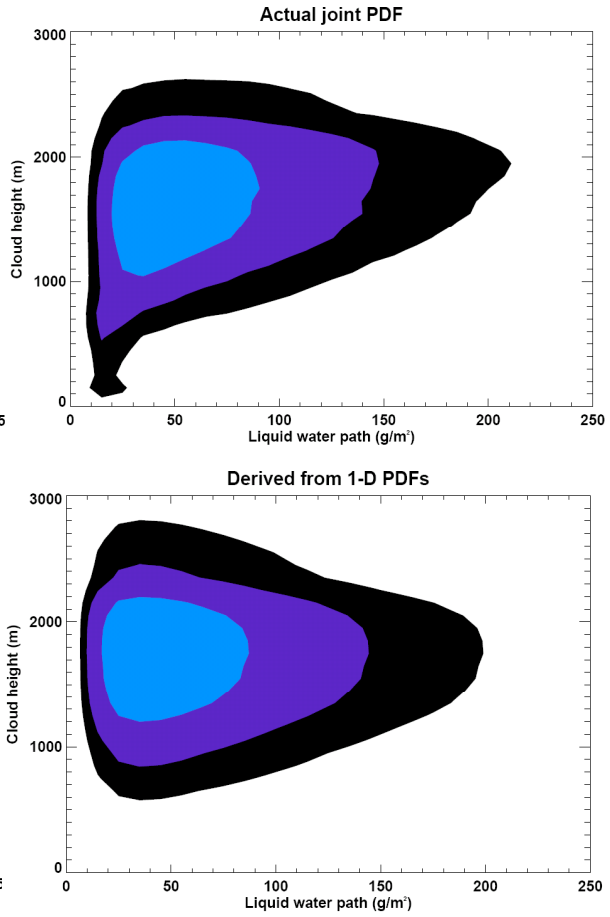
p = 0.96

LWP vs. SST



p = 0.05

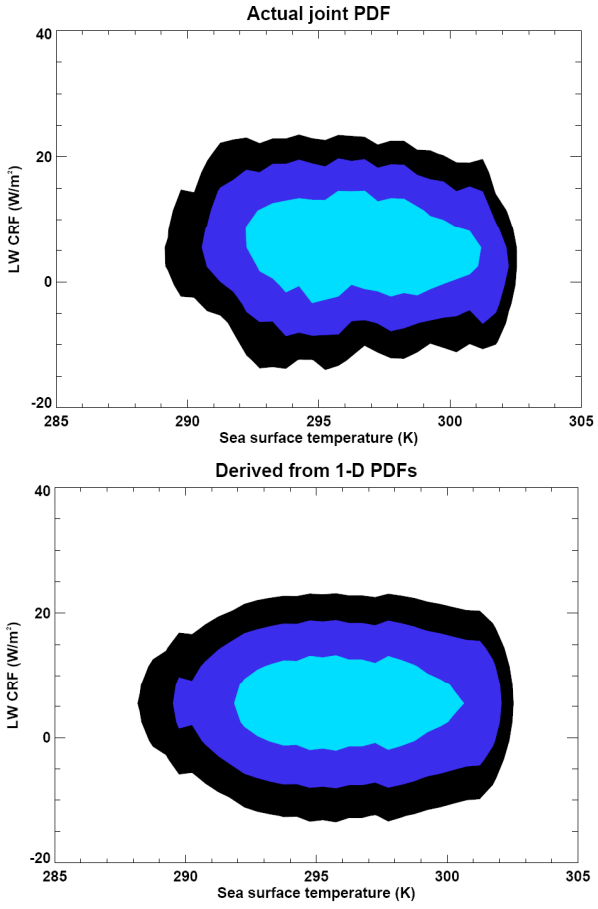
Cloud top vs. LWP



p < 0.01

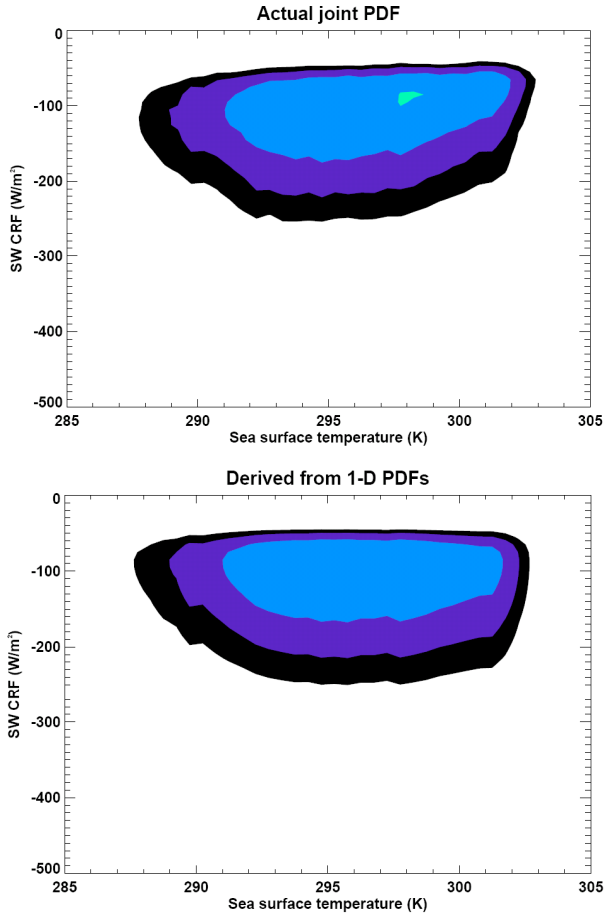
Results – Boundary-layer stratocumulus

LW CRF vs. SST



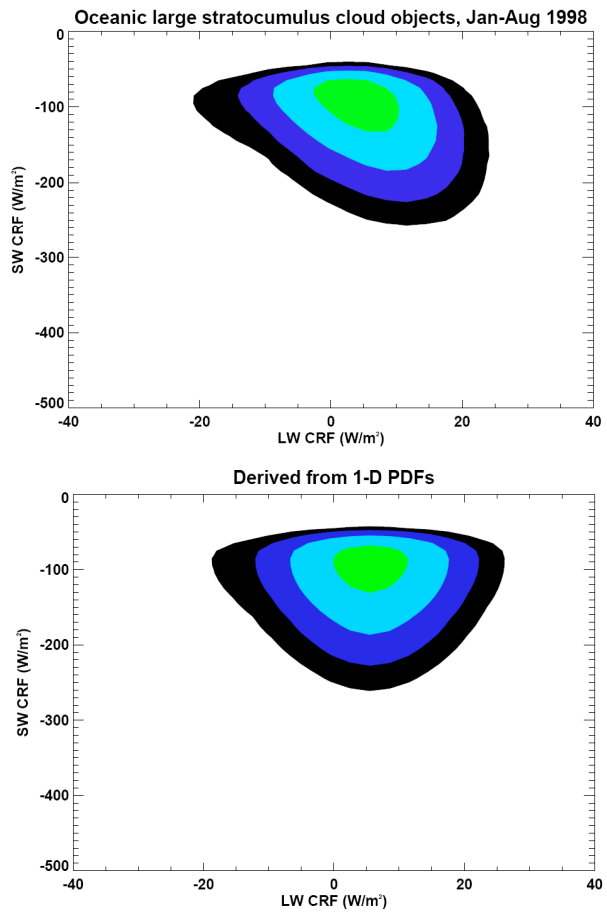
p = 0.58

SW CRF vs. SST



p = 0.24

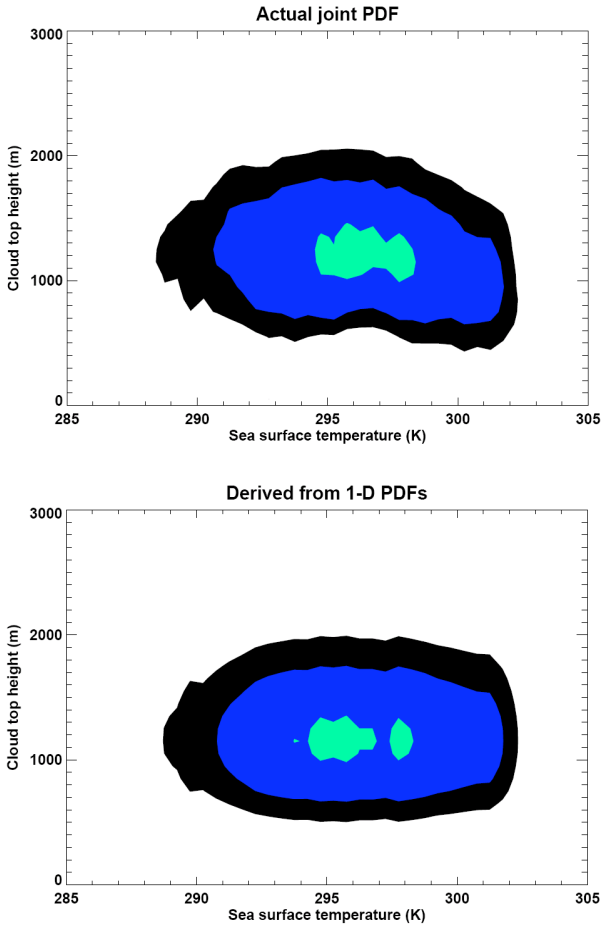
SW CRF vs. LW CRF



p < 0.01

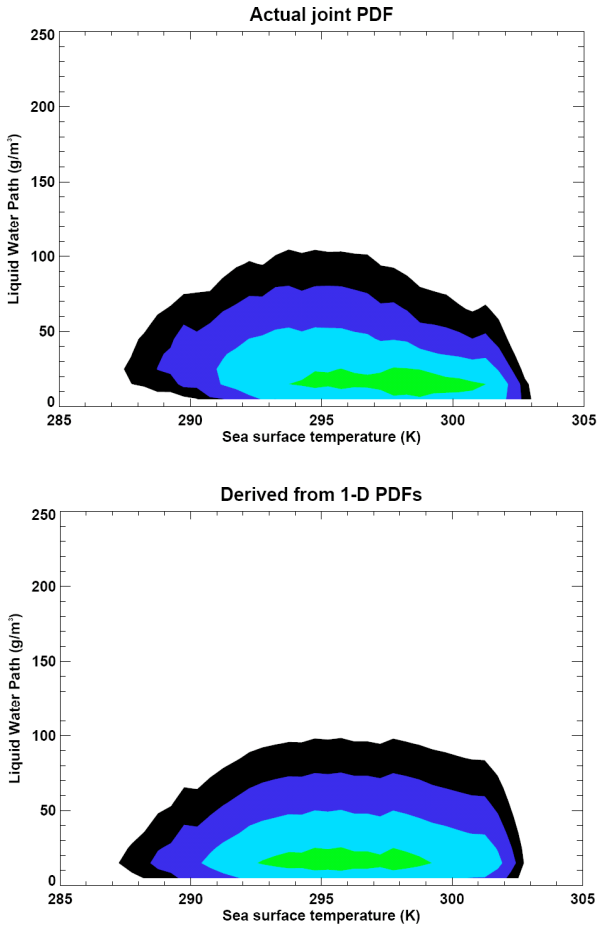
Results – Boundary-layer stratocumulus

Cloud top vs. SST



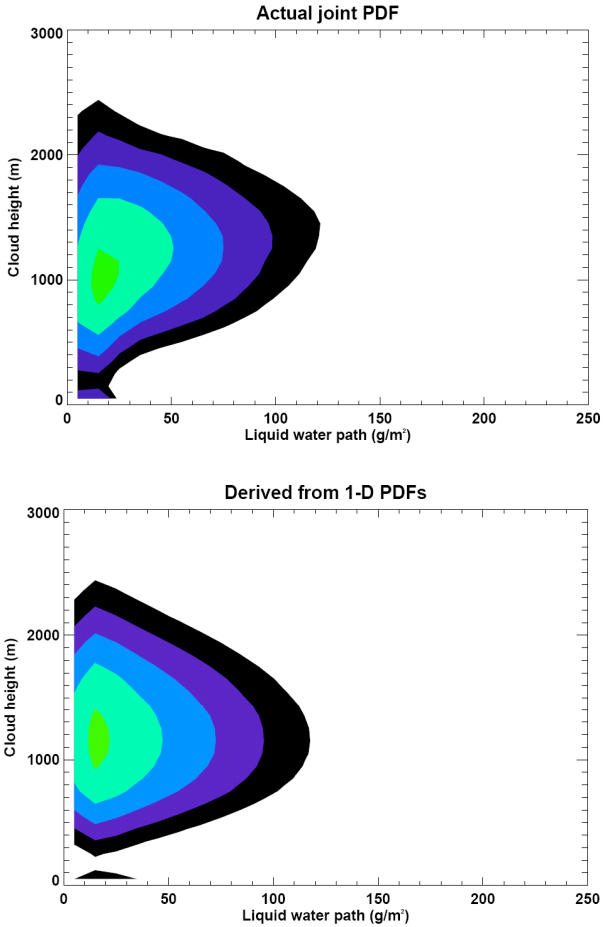
p = 0.66

LWP vs. SST



p < 0.01

Cloud top vs. LWP



p < 0.01

Summary and future work

- Joint PDFs and the bootstrap method can be combined to determine whether a “non-random” relationship exists between two variables.
- Deep convection – little or no dependence of LW or SW CRF on SST, but they are correlated with one another. Strong tendency for the “tail” of the IWP distribution to be associated with high cloud tops.
- Stratus, stratocumulus: Somewhat similar results for CRF. LWP does seem to depend on SST.
- Many more cloud variables and types to examine in the future.
- These joint PDFs should be a good tool for model (in)validation.

Bootstrap significance test